XIX.—*Notes on* Phoronis hippocrepia. *By* F. D. Dyster, *Esq.*, *F.L.S.*

Read July 1st, 1858.

Having recently had an opportunity of examining the very remarkable creature, first described by Dr. Wright* under the above appellation, I was desirous of contributing some details, with respect to its structure, in addition to those contained in that author's observations.

The colony on which my observations were made appeared in a tank, on a small piece of hard limestone which had been in the aquarium for a considerable time (I believe, some months), and which, covered with *Serpulæ* and other tubicular Annelids, and *Actiniæ*, was clearly derived from between tide-marks. To the naked eye, the *Phoronis* presents very much the appearance of *Cycloum*, but is rather more robust in build. The animals grow closely aggregated together, each individual inhabiting a tube buried in holes in the rock, but which does not project beyond its surface, and is considerably larger than the body: the tube is membranous and flexible, and appears to be formed by the incorporation of mud with an exudation furnished by the worm. In colour they present the silvery whiteness of the Polyzoa. They differ greatly in size, varying from $\frac{1}{16}$th to $\frac{5}{16}$ths of an inch in length (when fully protruded), of which length the tentacula make about $\frac{1}{6}$th; the breadth of the body is from $\frac{1}{100}$th to $\frac{1}{33}$rd of an inch, and the spread of the tentacula from $\frac{1}{16}$th to $\frac{3}{16}$ths of an inch. The body is cylindrical, slightly flattened on the hæmal surface, and semitransparent, presenting no trace of somites, annulations, setæ, or uncini. Truncate obliquely forwards and backwards, with a slight dilatation at the summit, it is crowned with a double row of tentacles springing from the two margins of a horseshoe-shaped lophophore, round the rami of which they are continued, recalling most vividly the cephalic apparatus of the hippocrepian Polyzoa. The outer row of tentacles spread into a cup, while the inner row arch towards each other, covering the space between the arms of the horseshoe, interlacing at their tips, and forming a cradle for the ova; the tentacles are filiform, silvery white, varying in number from 16 to 86, and united for a short distance from their bases by a delicate membrane. The motions of the tentacles are individually voluntary, and somewhat sluggish. The creature itself is timid; and the slightest touch, or any jar communicated to the water, causes it to withdraw with great activity: but the tips of the tentacles always protrude from the tube. The whole body is in constant gentle swaying motion, and is capable of considerable extension as well as protrusion. The animals are provided with great power of reproducing lost parts. An abstracted head is renewed within 48 hours, not completely developed, but with a serviceable mouth and its covering valve and stumpy tentacles which do their work of providing food. The tentacles are

* Edinburgh New Philosophical Journal, vol. vii. p. 313, tab. vii.

situated as in the Polyzoa, in lines, and not (as in many tubicular Annelids) all over the surface. They exhibit no trace of thread cells, and do not appear to be used as organs of prehension, but provide the food required by the worm by the current produced by the cilia. The body is not ciliated externally. Below and between the rami of the lophophore are two somewhat sigmoid ridges, which are the terminations of the oviducts. In some individuals, and always in large ovigerous specimens, at the posterior inner margin of the concavity of the lophophore, are seen two nearly circular lips, apparently with a perforation in their centre. Their use I cannot indicate. They may possibly be the terminations of the sperm-ducts; but as when the worm is in a position to exhibit the protrusion of the ova, these organs are hidden, I am unable to say whether any action occurs in them simultaneously with the deposition of eggs. The integument of the body is composed of a very delicate epidermis, beneath which are bundles of longitudinal muscular fibres, connected transversely by others, shorter and more delicate. The length of the largest specimens dug out from the rock would vary from $\frac{1}{2}$ to $\frac{3}{4}$ths of an inch.

Between the two rows of tentacles, on the neural side of the body, but nearer the hæmal row, is the mouth, which is somewhat elliptic, ciliated, and surrounded by a muscular sphincter, and covered by a delicate transparent marginated crescentic lip, attached by its concave edge to the convex portion of the lophophore. The mouth opens into a delicate expansible (non-ciliated?) œsophagus, which occupies the middle of the body. I have failed to detect the bands of areolar tissue alluded to by Dr. Wright as the stays of the alimentary canal. Just below the portion of the body protruded from the tube, the œsophagus opens, apparently through a sphincter, into an oblong stomach, richly ciliated, in which the food revolves rapidly in pellets, as in Pedicellina. What lies beneath the stomach I am unable to state decisively. The lower part of the body is so deeply imbedded in the hard rock, and its substance so fragile, while the tube is comparatively so tough, that very many hours of effort failed to extract one in perfect integrity; and the lower portion is so opaque that its walls do not permit its contents to be seen. I believe, however, that the stomach terminates in a very capacious intestine, which, filled with fæces, occupies the lower portion of the body, and which, traversing the whole tube and gradually narrowing, ascends again to terminate in a circular anus lying a little above, behind, and between the ridges made by the oviducts between the extremities of the rami of the lophophore The intestine lies above the œsophagus and the great blood-vessel, but beneath the oviduct. It is exceedingly delicate in structure, and can scarcely be made out except by its contents. It is not ciliated. The fæces are voided by jerks, in fusiform pellets connected by slender filaments, and frequently equal in length the whole exposed portion of the body.

The only organs to which hepatic functions could be attributed were some coloured cells on the walls of the stomach.

I could detect no nervous system: but this part of the organization demands further investigation; and it is possible that the two obscure organs mentioned as being present at the posterior part of the floor of the lophophore may be œsophageal ganglia. There are no eye-spots; nor does the animal show any sensibility to the influence of light.

Above the œsophagus, and attached to it by one margin, lies the great blood-vessel,

which for convenience may be called the artery. Along it the blood rushes upwards in a powerful stream, until it arrives at the base of the lophophore, where it bifurcates, giving a branch to each of the rami. These branches open into sinuses which extend all round the lophophore; and a twig is given off to each tentacle. The blood pursues its course to the extremity of the tentacles, which are provided with contractile vessels, tied down on one side, free on the other. The progress of the blood is not uniform in the tentacles, as it will be frequently seen to be ascending one while it is descending another, and sometimes the stream may be observed to recede from one tentacle and then fill the adjoining one instead of falling back into the general circulation. Two venous trunks open from the sinuses above and behind the arterial branches, and then proceed downwards, half encircling the œsophagus, till they unite in a large vessel on its neural surface. The blood moves by pulsations in the artery, at the rate of from twelve to fifteen beats a minute, the vessel contracting on it as it passes upwards, and remaining empty in the intervals between the beats. The returning stream through the neural vessel is perfectly continuous. In the course of the body the neural and hæmal vessels are connected by numerous capillary loops; and when the upper portion of the body is removed, the circulation is quickly re-established through the loops nearest the point of scission, and carried on as powerfully as before.

The blood consists of a colourless liquor sanguinis, densely charged with red globules of irregular shape and size, varying from circular to elliptical, flattened and somewhat concave on one side. In length they vary from $\frac{1}{3200}$th to $\frac{1}{1700}$th of an inch. The thickness is about $\frac{1}{8000}$th. All are provided with one, many with two nuclei of granular appearance, about $\frac{1}{20000}$th of an inch in diameter. They are exceedingly flexible, and turn about, double, elongate, and flatten when pressed for room by meeting other globules in the capillaries, exactly as globules of human blood do when seen coursing about under thin glass. There are no colourless corpuscles; and very careful watching detected no *Amœba*-like movements. They coagulate in masses which appear homogeneous, the nuclei only remaining visible. Treated with acetic acid, the cell-lining contracts, and all the globules assume a perfectly spherical form. There seems no ground for supposing that any special heart-like organ is concerned in the circulation of *Phoronis*. At whatever portion of the body section was made, after the shock of separation was recovered from, the pulsations of the hæmal vessel were renewed with the same vigour as before; and this occurred in the posterior extremity of one individual which was dug out to nearly its full extent.

The ovary lies below the stomach, and is, I believe, single. It is a long cylindrical vessel, pyriform at its base, perfectly transparent, and scarcely distinguishable except by its contained eggs, which appear to be attached to the inner surface. The ova are slightly elliptic, granular, about $\frac{1}{1000}$th of an inch in diameter: the individuals of which the ovaries were examined were all young; and there was no difference in the size or development of the ova. No specimen was observed without an ovary; but in only one spermatozoa were found. The body of these measured from $\frac{1}{1600}$th to $\frac{1}{1100}$th of an inch, with a filiform tail of equal length.

The ova when deposited are white, spherical, about $\frac{1}{200}$th of an inch in diameter, and not ciliated. The oviduct lies above the rectum, on the hæmal surface, immediately

under the integument, and is not ciliated. The ova lie in its upper and visible portion for some hours, vibrating backwards and forwards under the influence of the wave of blood in the hæmal vessel. They are driven slowly upwards, till they arrive between the two ducts which appear as ridges under the rami of the lophophore. The oviduct here seems to contract in its dimensions; and the ova assume a cylindrical form. They pause here for about half an hour; but at length the upper end of the cylinder dips suddenly downwards, passes into the hollow ridge, and then mounting through it, is discharged in a spherical form into the space between the inner tentacles, to which the ova adhere by a glutinous exudation. They are voided alternately through each ridge, and form a compact white mass, separable only with considerable difficulty, on each side of the space in the concavity of the horseshoe, shadowed over by the interlacing extremities of the inner tentacles. They vary in number from 10 to 80. When first extruded, they are granular with a clear margin, and show the usual germinal spot on pressure. In a few hours, cilia are developed all over the surface; and two depressions appear on the circumference, indicating a circular groove. This groove rapidly deepens; and within twenty-four hours the young exhibit distinctly a cephalic and an abdominal segment; anteriorly the line of separation deepens; and the abdominal portion becomes concave on the upper surface, alternately receding from and embracing the convex surface of the cephalic portion which lies above it. The cilia increase in length and power; and very soon, in certain positions, the alimentary canal becomes distinguishable. The cephalic segment divides into three lobes, of which the lateral are the longest and anterior, the central highest and posterior. The larva has now great power of locomotion, and quits the parent-nest when about forty-eight hours old.

The principal point of interest in the *Phoronis* is the indubitable presence of blood-corpuscles in proper closed vessels of the circulatory system. Von Siebold* is obscure and brief on this subject, and simply says—"the blood of the Annelids . . . is composed of a liquid containing globules . . . which are always colourless and of a spherical form." Milne-Edwards† says that, in the Vertebrata, "la couleur rouge du sang est due aux globules que ce liquide charrie; chez les Vers à sang rouge, c'est en dissolution dans le liquide lui-même, que se trouve la matière colorante. . . . Les globules ne jouent dans cette coloration aucun rôle essentiel, et d'ordinaire ces corpuscules paraissent même manquer complétement dans ce liquide. . . . M. de Quatrefages a été même conduit à penser que dans l'immense majorité des cas, le sang rouge des Annélides est complétement privé des globules quelconques. Il n'a rencontré qu'une exception à cette règle, et elle lui a été fournie par une espèce de Glycère des côtes de la Manche, chez laquelle il a trouvé des globules rouges et de forme discoïde, nageant dans un liquide incolore. Mais M. Williams‡, qui a publié récemment une série nombreuse d'observations sur le fluide nourricier des animaux invertébrés, affirme que cette exception n'existe pas; que les globules rouges décrits par M. de Quatrefages se trouvent dans le liquide de la cavité générale du corps, et non dans les vaisseaux sanguins, et que dans aucun Annélide le sang proprement dit (ou sang coloré)

* Von Siebold, Comp. Anatomy, translated by Burnett, vol. i. p. 168.

† Leçons sur la Physiologie, tome i. pp. 106–108 et note.

‡ On the Blood proper and Chylaqueous Fluid of Invertebrate Animals.—Philosophical Transactions, 1852, p. 632.

ne renferme des éléments 'morphotiques' quelconques, c'est-à-dire des globules." And Mr. Huxley* says, "it may be considered an established fact that, whatever the functions of the varied vascular system and its contents in different classes of the Annuloida, they have nothing to do with the blood or the blood-vessels. The latter are entirely absent in the Annuloida at present known, the blood being simply contained in the perivisceral cavity and its processes." Nothing short of the most patient observation would have induced me to state a fact which is incompatible with the opinions and observations of Mr. Huxley and Milne-Edwards; but while my own investigations leave no room for doubt that the proper fluid of the vascular system in *Phoronis* consists of a colourless liquor sanguinis densely crowded with red corpuscles, I am confirmed in the probability of the fact by the discovery of globules in the vascular system of *Glycera* by M. de Quatrefages, against whose accuracy I do not think the sweeping statement of Dr. Williams is a sufficient balance. Not only is it easy to define the vessels which contain the corpuscles in the living worm, but I have several times, under the compressorium, succeeded in isolating a capillary loop with its string of globules.

There are one or two other points in which the *Phoronis* deviates very remarkably from the Annelidan type. In the position of the anus at the anterior extremity in close proximity to the mouth, it stands, I believe, alone, though Mr. Busk has reminded me of the analogy which this presents to the arrangement in *Sipunculus*, the annulose form of the Echinoderms. The development of the nervous system is very small—indeed at present, as before remarked, I cannot do more than guess at the presence of two œsophageal ganglia, —while there is no trace of eye-spots, nor does the creature, like *Serpula* and *Sabella*, exhibit any appearance of sensibility to light. Negatively, Dr. Wright confirms this view inasmuch as he makes no allusion to the nervous system, while Professor Allman† distinctly says he could perceive none. In all the Capitibranchiate Annelids the pharynx is short and muscular, while in *Phoronis* it is long and presents no appreciable trace of muscular structure. In the same division, the alimentary tube has numerous dilatations corresponding to the somites, while in *Phoronis* it is a simple canal, and there exist neither external segments nor internal septa, and there is no approach to pedal lobes, hooks, paleæ or bristles. I believe that in *Phoronis* there is no perivisceral cavity; at all events, there are no corpuscles such as are present in the perivisceral fluid of other Annelida.

I am indebted to my friend Mrs. Brett for the figures, which she has translated into beauty from my rough diagrams.

* Lectures on Natural History, Medical Gazette, vol. xxxiv. p. 385.

† Freshwater Polyzoa (Ray Society), p. 55. note.

EXPLANATION OF THE PLATE.

Tab. XLIV.

Figs. 1, 2, 3. Side, vertical, and front views of *Phoronis hippocrepia*.

Fig. 4. *a*. Lophophore.
b. Œsophagus.
c. Hæmal vessel overlying œsophagus.
d, d, d. Ova overlying hæmal vessel.
e, e. Branches of hæmal vessel opening into sinus of lophophore.
f, f. Venous branches uniting beneath the œsophagus, and forming neural vessel.
g, g. Ridges forming terminations of oviduct.
h, h. Uncertain organs.

Fig. 5. View of vascular system.
a. Lophophore.
b. Venous branches.
c. Neural vessel.
d. Hæmal vessel.
e, e. Capillary loops connecting neural and hæmal vessels.
f. Œsophagus.
g. Mouth with crescentic lip.
h. Tentacula with twigs opening into sinus of lophophore.

Fig. 6. Diagram of lophophore seen from above.
a. Lophophore.
b. Bases of tentacula.
c. Mouth covered with crescentic lip.
d. Anus.
e. Terminations of oviduct.

Fig. 7. Blood-corpuscles, magnified 460 diameters.

Fig. 8. Ovary.

Fig. 9. Spermatozoa, magnified 460 diameters.

Fig. 10. Ovum just separated.

Figs. 11, 12, 13. The same in more advanced stages of development, the last about 48 hours old.